Competency 4.4 **Environmental compliance personnel shall demonstrate the ability to appraise the contractor's program(s) to assess compliance with the requirements for environmental radiation protection.**

1. SUPPORTING KNOWLEDGE AND/OR SKILLS

a. Assess whether the effluent monitoring from a facility meets the requirements of DOE Order 5400.5, *Radiation Protection of the Public and the Environment;* 10 CFR 834, *Radiation Protection of the Public and Environment;* and DOE/EH-0173T, *Environmental Regulatory Guide for Effluent Monitoring and Environmental Surveillance*.

b. Assess whether adequate methods are used to characterize effluents for purposes of limiting doses to the public in accordance with regulatory and As Low As Reasonably Achievable (ALARA) limits.

c. Assess whether the environmental radiological protection program is in accordance with 10 CFR 834, *Radiation Protection of the Public and Environment.*

2. SUMMARY

DOE Order 5400.5, *Radiation Protection of the Public and the Environment,* establishes standards and requirements for operations of DOE and its contractors with respect to protection of the public and the environment against undue risk from radiation. The Order is divided into four chapters that discuss the general topics covered in the Order, requirements for radiation protection of the public and the environment, derived concentration guides (DCGs) for air and water, and residual radioactive material.

NOTE: DOE Order 5400.5 is in the process of being codified under 10 CFR 834.

Chapter I, General Summary

The first chapter serves as a general introduction. The chapter highlights International Commission of Radiation Protection (ICRP) recommended methodology, the DOE primary dose standard, the ALARA philosophy, treatment technologies, and compliance with the Order.

Specifically, DOE:

- Adopts the ICRP 26/30 methodology recommended in 1977. (**NOTE:** Since the issuance of DOE Order 5400.5, the ICRP has published new recommendations on radiation protection, ICRP 60.)
- Uses a primary dose standard for the public of 100 mrem in a year. This is an effective dose equivalent (EDE) from all sources and all pathways.
- Adopts the ALARA philosophy. This means that in this Order, ALARA is no longer a recommended practice, but a required part of the radiation protection program (RAP).
- Adopts the Best Available Technology (BAT) as the appropriate level of treatment for liquid wastes at the point of discharge.
- Calls for the phasing out of soil columns to prevent the build up of contamination in soils and groundwater, thereby protecting the environment.
- Requires compliance with the Order through effluent monitoring, environmental surveillance, computer modeling, and dose conversion factors.

Chapter II, Requirements for Radiation Protection of the Public and the Environment

The primary dose limit for members of the public is 100 mrem EDE in a year from all sources and all pathways. The EDE was originally defined by the ICRP when it introduced a risk-based system in ICRP 26. The EDE allows the summation of external and internal doses. The primary dose limit, therefore, includes exposures from sources external to the body during the year and the committed EDE from radionuclides taken into the body during the year. This limit does not apply, however, to doses from medical exposures and consumer products. The limit does not generally apply to naturally occurring radioactivity and accident conditions. Authorization to exceed the primary standard is possible, but requires approval from DOE officials (EH-1).

Other limits specified in this chapter are:

• Airborne emissions (40 CFR 61)	10 mrem (0.1 mSv) EDE
• Spent nuclear fuel, high-level, and transuranic wastes (40 CFR 191)	25 mrem (0.25 mSv) whole body 75 mrem (0.75 mSv) any organ
• Drinking water (40 CFR 141)	4 mrem (0.04 mSv) EDE at the tap 5E-9 µCi/ml (radium-226 + radium-228) 1.5E-8 µCi/ml gross alpha

The regulation of airborne emissions is required under the Clean Air Act, which, in turn, precipitated the issuance of 40 CFR 61, *National Emission Standards for Hazardous Air Pollutants*. The airborne limit of 10 mrem is based on releases to the atmosphere from routine DOE activities. Exposures from radon-220 (Rn-220), radon-222 (Rn-222), and their progeny are subject to separate DOE limits.

Note that the limits for spent nuclear fuel facilities, etc., are not in EDE units since both whole body and organ doses are specified. Simply stated, 40 CFR 191, *Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Radioactive Wastes*, was written several years ago using ICRP 2 methodology, which treated external and internal doses separately.

The drinking water limits in this order are based on 40 CFR 141, *National Interim Primary Drinking Water Regulations* (Safe Drinking Water Act), a regulation that was also written prior to the advent of the EDE. However, it is listed here as an EDE because DOE has chosen to do so. The 4-mrem limit applies to community water systems that serve at least 15 connections or regularly serve an average of at least 25 individuals daily at least 60 days out of the year.

As stated earlier, the ALARA approach is now required for DOE activities and facilities that could result in public doses. DOE Order 5400.5 lists several factors that should be considered in an ALARA program. Quantitative cost-benefit analyses of many of these of these factors can be both expensive and difficult to evaluate. Therefore, flexibility is given in the Order to perform qualitative ALARA analyses in those instances where doses are well below the limits and requirements of the National Environmental Policy Act (NEPA) have been met. Analyses of a quantitative nature are definitely required, however, when potential doses approach the limit.

To assist DOE personnel and its contractors in the implementation of the ALARA process as it relates to DOE Order 5400.5, DOE issued *DOE Guidance on the Procedures in Applying the ALARA Process for Compliance With DOE 5400.5*. DOE now requires tightened controls on the discharge of liquid effluents from its facilities. The objective is to protect resources such as land, surface water, and groundwater from undue contamination. This has created the need for an evaluation of BAT. According to the Order, a BAT review is required for liquid wastes containing radionuclides discharged to surface waters if these waters would contain, at the point of discharge and prior to dilution, radioactive material at an annual average concentration greater than the DCGs (listed in Chapter III) for liquids. A DCG, by definition, is the concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode, would result in an EDE of 100 mrem (1 mSv). For multiple releases, the sum of fractions method is used where the concentration of each radionuclide is divided by its respective DCG, summed for each radionuclide, and compared to one (meaning the sum of fractions cannot exceed 1).

Several factors affect the BAT review, including the age of the facility; cost; and environmental, safety, and public impacts. At the present time, there is an exemption for tritium, since no BAT is available. DOE issued an interim final report, DOE/EH-263T, *Implementation Manual for Application of Best Available Technology Processes for Radionuclides in Liquid Effluents*, in June 1992 to provide guidance and explanation of the requirements for BAT effluent control found in DOE Order 5400.5.

To prevent the buildup of radioactivity in sediment, limits exist for the levels of alpha and beta-gamma settleable solids found in a liquid process waste stream released to natural waterways.

For gross alpha: <5 *picocuries per gram (*pCi/g) above background

For gross beta: <50 pCi/g above background

To protect native animal aquatic organisms, the absorbed dose from exposure to radioactive material in liquid wastes discharged to natural waterways must not exceed 1 rad per day. This limit is based on information contained in NCRP 109, *Effects of Ionizing Radiation on Aquatic Organisms*.

The use of soil columns (trenches, cribs, ponds, drain fields, etc.) for retaining, by sorption or ion exchange, suspended or dissolved radionuclides from liquid waste streams, must be phased out and replaced by an acceptable alternative. Each facility is responsible for developing a plan and schedule for alternate disposal methods.

The BAT review process is implemented in some instances not just for liquid discharges to surface waters (as noted above), but also for releases to sanitary sewers where radionuclide concentrations, averaged monthly, would otherwise be greater than 5 times the DCG values for liquids (given in Chapter III) at the point of discharge.

In the codification of DOE Order 5400.5 to 10 CFR 834, total curie (Ci) limits may apply. These limits (as stated in the draft version of 10 CFR 834) are:

- 5 Ci hydrogen-3
- 1 Ci carbon-14
- 1 Ci all other radionuclides

Compliance with the dose limits in the Order are demonstrated through documentation and recordkeeping, effluent monitoring, environmental surveillance, dose conversion factors, Environmental Protection Agency (EPA)-approved computer models, comparison with derived concentration guide (DCG) values, and other methods with the approval of the Assistant Secretary for Environment, Safety and Health (EH-1).

<u>Chapter III, Derived Concentration Guides for Air and Water</u>

The DCG values listed in this chapter are provided as guideline reference values for conducting radiological environmental protection programs at operational DOE facilities and sites. Derived Air Concentration [DAC] values for occupational intake of radionuclides through inhalation can be found in the appendices to 10 CFR 835.)

DCG values are included for each of three exposure modes: ingestion of water, inhalation of air, and immersion in a gaseous cloud. Other potentially significant exposure pathways are not included in this chapter; therefore, specific pathway analyses would have to be performed for calculating public radiation doses.

Since the DCG values for internal exposure are based on a cumulative effective dose equivalent (CEDE) of 100 mrem, comparison with the DOE drinking water criterion of 4 mrem is accomplished by taking 4% of the DCG values for ingestion.

Chapter IV, Residual Radioactive Material

This chapter provides radiological protection requirements and guidance for the cleanup of residual radioactive material and the management of the resulting wastes, residues, and release of property. The criteria for cleanup of residual radioactive material used in this chapter originally applied to sites under the Formerly Utilized Sites Remedial Action Program (FUSRAP) and the Surplus Facilities Management Program (SFMP). These criteria now apply DOE-wide.

Residual radioactive material, as used in this chapter, includes residual concentrations of radionuclides in soil, airborne concentrations of radon progeny, external gamma radiation levels, surface contamination limits, and radionuclide concentrations in air or water resulting from or associated with any of the above.

The basic dose limit for the public from exposures to residual radioactive materials above natural background levels is 100 mrem (1 mSv) EDE. This limit applies to all sources and all release pathways from the facility or site in question. Separate limits apply to radon and its progeny.

For soil, residual concentrations of radioactive material are defined as those concentrations exceeding background concentrations when averaged over 100 square meters. Generic guidelines, (i.e., guidelines independent of the property and that, therefore, apply to all facilities) are taken from existing radiation protection standards. For the radionuclides radium-226 (Ra-226), radium-228 (Ra-228), thorium-228 (Th-228), and thorium-232 (Th-232), these generic values are:

- 5 pCi/g averaged over the first 15 cm of soil below the surface.
- 15 pCi/g averaged over succeeding 15 cm layers of soil more than 15 cm below the surface.

Site-specific release limits require a pathway analysis utilizing specific property data and the computer program *RESRAD*, which was developed by the Argonne National Laboratory. Hot-spot criteria also exist.

Limits for airborne radon decay products are taken from 40 CFR 192. The objective of the remedial action is to achieve an annual average (or its equivalent) of 0.02 working level (WL), including background. In no case shall the radon progeny concentration exceed 0.03 WL (including background).

The limit for external gamma radiation (taken as an average level above background) is 20 µR/h inside a building or habitable structure on a site to be released without restrictions. This value similarly comes from 40 CFR 192, *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings.*

Surface contamination guideline values, expressed in typical units of dpm/100 cm^2, are detailed in the table that follows. These guidelines were adapted by DOE from U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors* (1974), and the NRC publication, *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for By-product, Source, or Special Nuclear Material* (1982). The guideline values are applicable to existing structures and equipment.

Surface Contamination Guidelines

Allowable Total Residual Surface Contamination (dpm/100 cm^2)			
Radionuclides	**Average**	**Maximum**	**Removable**
Transuranics, I-125, I-129, Ra-226, Ac-227, Ra-228, Th-228, Th-230, Pa-231	RESERVED	RESERVED	RESERVED
Th-natural, Sr-90, I-126, I-131, I-133, Ra-223, Ra-224, U-232, Th-232	1,000	3,000	200
U-natural, U-235, U-238, and associated decay product; alpha emitters	5,000	15,000	1,000
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000	15,000	1,000

The Order establishes authorized limits for residual radioactive material that should be set equal to the generic or DCGs, unless it can be shown that the DCGs are not appropriate for use at the specific property.

Residual radioactive material must also be managed. DOE Order 5400.5 discusses several ways this can be achieved:

- Interim storage - Control and stabilization features shall be designed to provide for a minimum life of 25 years and an effective life of 50 year*s*. Provisions for the control of Rn-222 and groundwater concentrations, quantities of residual radioactive material, site access, and use of onsite material must be established.

- Interim management - Generally applies when the residual radioactive material is in inaccessible locations and would involve a significant financial burden to remove.
- Long-term management - For uranium, thorium, and their decay products, control and stabilization features shall be designed to provide for a minimum life of 200 years and an effective life of 1,000 years. Control of Rn-222 emanation rates, groundwater concentrations, residual radioactive material, site access, and the use of onsite material must be established. The long-term management of other radionuclides is conducted under the provisions of DOE 5820.2A, *Radioactive Waste Management*.

Supplemental limits and exceptions can be requested in certain circumstances where the guidelines or authorized limits established for the site in question are not appropriate. Supplemental limits can allow uncontrolled release of the site without radiation restrictions; however, the basic dose limit of 100 mrem must still be achieved. Exceptions require that some restrictions be placed on the site (no farm use, for example). Any exceptions must be justified and ensure that the basic public dose limits are met. Control of residual radioactive material must still be established.

10 CFR 834 is a proposed rule covering basic areas relating to radiation protection of the public and the environment. It establishes dose limits for exposure of the public to radiation and requires reporting of doses above specified levels. It requires the assessment of all releases of radioactive materials and all doses and potential doses to the public from DOE and contractor activities so as to ensure ALARA policy management. It provides requirements for the management of radioactive materials in soil and water and requires sites to establish groundwater protection programs. It provides requirements for the decontamination, survey, management, storage, disposal and release of buildings, land, equipment, and personal property containing residual radioactive materials. It requires an environmental radiological protection program (ERPP) for each DOE activity to set forth the program, plans, and other processes to protect the public from exposures to radiation. Finally, it requires effluent monitoring and environmental surveillance programs as part of the ERPP.

DOE EH/0173T, DOE *Environmental Regulatory Guide*, addresses liquid and gaseous effluent monitoring in Chapters 2 and 3, respectively. Meteorological monitoring is discussed in Chapter 4. These chapters are intended to assist each DOE-controlled facility meet the requirements of DOE Order 5400.1, *General Environmental Protection Program Requirements*, and DOE Order 5400.5, *Radiation Protection of the Public and the Environment*.

Chapter 2 discusses general criteria and monitoring requirements, performance standards for liquid effluent monitoring systems, sampling and monitoring systems design criteria and considerations, alarm levels, and quality assurance. Monitoring of liquid wastes should be performed to:

- Demonstrate compliance with DOE Order 5400.5 (specifically Chapter 2).
- Quantify radionuclides released from each discharge point.

- Alert appropriate personnel of "upsets" in processes and emissions controls.

Continuous radionuclide monitoring is recommended for routine releases that could exceed one 1 DCG at the release point when averaged over one year or unanticipated releases exceeding one DCG averaged over one year. Continuous sampling combined with frequent analyses can substitute for continuous monitoring if emissions cannot be detected by technically current continuous monitoring devices. Appropriate statistical parameters should be considered to determine the accuracy of sampling results. The regulatory guide points out that the level of monitoring effort is determined by the importance of the sources during routine operations and the potential for accidental releases to the environment and dose to the general public.

Performance standards for a liquid effluent monitoring system are based on a careful characterization of several parameters. These include the source(s), pollutant(s), sample collection system(s), treatment system(s), and final release point(s) of the effluents.

If a facility is new or has been modified, a preoperational assessment is recommended to determine the impact on effluent release quantity, quality, and sensitivity of the monitoring or surveillance system. This assessment should be used to determine liquid effluent types and quantities, and facility monitoring needs. It is important that the system perform to a level that allows compliance with DOE Order 5400.5 (specifically, being able to detect radionuclide concentrations at or below the DCG in addition to meeting reporting requirements). Sufficient sensitivity regarding statistical detection levels is advocated.

Performance standards include consideration of continuous monitoring/sampling, sampling systems, calibration of monitoring and sampling systems, and environmental conditions.

Design criteria associated with liquid effluent systems exist to promote representative sampling. The following general criteria assist in meeting that objective:

- Location for sampling and monitoring
- Use of a highly reliable sampling pump where needed to provide uniform continuous flows
- Redundant sampling collection systems or an appropriate alternative
- Sampling ports located sufficiently downstream of the final feeder line to promote complete mixing
- Sampling a proportional amount of the full effluent flow
- Accuracies within ±10% regarding effluent streams and sample-line flows
- Emphasis on maintaining structural integrity of the effluent sampling lines

Design considerations for the liquid effluent monitoring systems include the following:

- Purpose - Monitoring provides a prompt signal if a significant release occurs. Written procedures are advocated to document the actions that should be taken if an abnormal signal is detected. Both in-line and off-line monitoring may be required to accommodate routine and emergency monitoring.
- General Design Criteria - The type of radiation influence whether actual direct measurements or sampling and analysis is required (or a combination thereof). Alpha emitters and some beta emitters pose concerns from a measurement perspective; therefore, sampling and analysis should be performed to quantify releases associated with these radiations. Gamma radiation can usually be detected by direct measurement. Shielding may be required for high background areas. In these cases, off-line monitoring is encouraged. Grab samples can be utilized for "batch" releases where the concentration of radioactivity is constant, but the release is of short duration. When "continuous" effluent streams are present, continuous monitoring and/or sampling should be performed. Environmental conditions influence the design of the monitoring/sampling system. Air conditioning and heating provide reliable system operation to minimize worker exposures; background dose rates are considerations in accessing the system for calibration and servicing. Shielding should be considered when warranted.

Alarms are recommended to provide timely warnings and signal the need for corrective actions prior to a release exceeding the limits or recommendations in Order 5400.5. The collection of a variety of samples (grab, continuous, or proportional) is encouraged to detect the levels of radioactivity before significant impacts on the public or the environment occur.

General quality assurance (QA) provisions are contained in Chapter 10 of the regulatory guide. Specific requirements should be detailed in a facility/site-specific QA plan.

Four basic sampling alternatives are noted in the regulatory guide:

- Offline periodic - Grab samples of waste streams are taken on a periodic basis, concentrated (if needed), and delivered to the laboratory.
- Off-line sequential -Time aliquots of the effluent are taken when a relatively constant waste stream flow rate is present.
- Off-line proportional - Known fractions of the effluent are collected on a continuous basis prior to laboratory analysis.
- Off-line continuous - Samples are continuously collected at a known, uniform rate.

In the laboratory, the presence of alpha, beta, and gamma radioactivity in liquid effluents can be determined in different ways. For example, the sample can be placed in a stainless steel vessel holding approximately 20 to 25 liters of water. Various detectors are utilized to detect the radioactivity. Alpha and beta radiations, for instance, can be detected using proportional or liquid scintillation counters while gamma radiation is detected with sodium iodide (NaI) scintillators. These monitors tend to be quite heavy, often weighing on the order of 2,000 to 3,000 pounds.

Chapter 3 of the DOE *Environmental Regulatory Guide* is devoted to airborne effluent monitoring. This chapter begins by stating that airborne emissions from a DOE-controlled facility should be evaluated and assessments made of the potential for release of radioactivity. This assessment is important in that it directly impacts the preparation of the site's effluent monitoring and environmental monitoring programs (discussed in DOE Orders 5400.1 and 5400.5, respectively).

The regulatory guide recommends that airborne emissions having the potential for causing doses exceeding 0.1 mrem EDE to a member of the general public (under a realistic scenario) for emissions in a year should be monitored. Chapter 3 describes various aspects of airborne effluent monitoring. These include general criteria and monitoring requirements, requirements for compliance with EPA regulations, performance standards for air sampling systems, design criteria for system components, point-source design criteria, alarm levels, and QA.

The following table, taken from the regulatory guide, lists the criteria for establishing an airborne emission monitoring program. As was the case for liquid effluent monitoring, the scope of the monitoring effort is dependent on the impact of the sources and the potential for accidental releases.

Criteria for Emission Monitoring	
Calculated Maximum Dose from Emissions in a Year to Members of the Public: H_E mrem [effective dose equivalent (EDE)]	Minimum Emission Monitoring Criteria*
$H_E \geq 1$	1. Continuously monitor emission points that could contribute $\geq$0.1 mrem in a year 2. Identify radionuclides that contribute $\geq$10% of the dose 3. Determine accuracy of results (±% accuracy and % confidence level) 4. Conduct a confirmatory environmental survey annually <u>or</u> Monitor at the receptor: 1. Continuously sample air at receptor 2. Collect and measure radionuclides contributing $\geq$1 mrem (EDE) above background 3. Establish sampler density sufficient to estimate dose to critical receptor given typical variability of meteorological conditions 4. Obtain prior approval from EPA
$0.1 < H_E < 1$	1. Continuously monitor emission points that could contribute $\geq$0.1 mrem in a year 2. Identify radionuclides that contribute 10% or more of the dose 3. Conduct confirmatory effluent monitoring at emission points where possible 4. Conduct a confirmatory environmental survey every few years
$H_E < 0.1$	1. Take periodic confirmatory measurements 2. Test to determine need to monitor by calculating dose (H_E) for normal operation, assuming that the emission controls are inoperative 3. Conduct a confirmatory environmental survey at least every five years

* Alternative criteria may be obtained through EH following coordination with EPA.

DOE-controlled facilities are subject to requirements put forth by the EPA. Regarding air emissions, the two main regulations of interest are:

- 40 CFR 61, *National Emission Standards for Hazardous Air Pollutants*. The specific emission standard of 10 mrem is found in Subpart H of this regulation.
- 40 CFR 192, *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings.*

The frequency for conducting continuous monitoring and/or sampling is stated in the previous table. Other performance parameters track very closely with those discussed under liquid effluent monitoring. This particular section differentiates the manner in which airborne emissions can occur, that is, "point" versus "diffuse" sources. Point sources imply a release from a single defined point (a vent or stack are typical examples). Diffuse sources cover much larger areas. Examples include ponds, contaminated areas, and structures without ventilation or with ventilation that does not have a well-defined release point. Diffuse sources, by their nature, receive significant attention in terms of their impact on public dose and the environment. The regulatory guide recommends that these sources be identified and assessed. Further, diffuse sources contributing a significant fraction of the public dose should not only be identified and assessed, but documented and verified annually.

The quantification of airborne emissions through the use of sampling and monitoring systems relies on such factors as timeliness, representative sampling, and adequate sensitivity. Characterizing and documenting sources of emissions requires consideration of several factors.

These include the identification of:

- Actual or potential radionuclides by type and concentration.
- Fallout and naturally occurring radionuclides.
- Materials of a biological or chemical nature that negatively impact on the goals of the sampling and monitoring program.
- Internal and external conditions such as environmental conditions, factors which lead to a complete loss of the system, and gas-stream characteristics.

This section of the regulatory guide offers extensive information on design criteria for "point" emission sources. Furthermore, several important references are noted to assist responsible individuals at DOE facilities with implementing these criteria. Each subsection under this topic is listed in the following table along with cited references. The reader is encouraged to consult these additional sources of information.

Point Source Design Criteria (Subsection Heading)	Reference(s)
Gas-Stream Characterization Methods (3.5.1)	EPA Methods 1,2,4; ASTM Annual Book of ASTM Standards (1985)
Location of Sample Extraction Sites (3.5.2)	EPA Method 1; ANSI N13.1-1969
Sample-Extraction Probes (3.5.3)	EPA Method 5; ANSI N13.1-1969
Sample Transport Lines (3.5.4)	EPA Method 5; ANSI N13.1-1969
Air Moving Systems (3.5.5)	Not Applicable
Air Flow Measurements (3.5.6)	DOE/EP-0096; ANSI N13.1-1969
Sample Collectors (3.5.7)	ANSI N13.1-1969
Continuous Monitoring Systems (3.5.8)	ANSI N42.18-1974 (R 1980); DOE/EP-0096; ANSI N317-1980

Chapter 4 of the *Environmental Regulatory Guide* addresses meteorological monitoring and its importance at DOE facilities regarding impacts on public health and safety and compliance with applicable laws and regulations. According to the regulatory guide, each DOE facility should establish a meteorological monitoring program that considers the magnitude of potential source terms, possible atmospheric pathways, distances from release points to critical receptors, and proximity of the site to other DOE facilities.

Atmospheric dispersion calculations utilized for the purpose of assessing doses can range from simple to complex. The Gaussian plume equation is often used to predict the concentration in the air at a specified downwind distance, y meters away from the plume centerline and z meters above the ground due to an elevated release.

$$\chi = \frac{Q'}{2\pi\sigma_y\sigma_z u}\left(e^{-0.5\left(\frac{h-z}{\sigma_z}\right)^2} + e^{-0.5\left(\frac{h+z}{\sigma_z}\right)^2}\right) e^{-0.5\left(\frac{y}{\sigma_y}\right)^2}$$

where:

- χ = concentration (Ci/m^3)
- Q' = release rate (Ci/s)
- u = average wind speed of plume (m/s)
- σ_y = horizontal dispersion coefficient (m)
- σ_z = vertical dispersion coefficient (m)
- h = effective stack (plume) height (m)
- y = horizontal distance at right angles to plume centerline (m)
- z = height above ground (m)

The Gaussian plume model is considered to be appropriate for facilities located in simple topographic settings. When this is not the case, DOE/EH-0173T recommends the use of more realistic dose assessment models.

3. SELF-STUDY SCENARIOS/ACTIVITIES AND SOLUTIONS

Activity 1

You have been assigned to an audit to determine whether a contractor complies with the effluent monitoring requirements under DOE Order 5400.5, 10 CFR 834, and DOE/EH 0173T, and, in addition, to assess the costs involved in bringing the facility up to an appropriate standard with respect to these requirements. What factors would you address during the audit with respect to these three documents?

Activity 2

You work for a DOE contractor and your company provides science education in a small teaching facility using a limited number of radionuclides for instructional purposes. One of the sources used is tritium (H-3). Since you must dispose of the tritium, and since the amount you use in the course of a year is very small, you decide to dispose of it by simply dumping it down the drain.

How would you justify this action to a DOE auditor? Would you be permitted, under DOE regulations, to dump as much as 5.9 Ci of H-3 down your drain over the course of a year?

Activity 3

You have been tasked with assessing (revising) your site's environmental radiological protection program (ERPP). Meanwhile, the final rule for 10 CFR 834 has just been published. It varies little from the draft document (Part II). What factors would you consider in determining if your facilities ERPP program meets or exceeds the requirements of 10 CFR 834?

Activity 1, Solution
(Any reasonable paraphrase of the following is acceptable.)

The contractor would be required to consider the following regarding DOE Order 5400.5:

- Are doses to members of the public in the vicinity of DOE activities evaluated and documented to demonstrate compliance with the dose limits of DOE Order 5400.5 and to assess exposures of the public from unplanned events?
- Are collective doses to members of the public within 80 km of the site evaluated and documented at least annually?
- Are analytical models used for dose evaluations appropriate for:
  - Characteristics of emissions?
  - Mode of release?
  - Environmental transport medium?
  - Exposure pathway?
  - Ingestion of food?
- Are the following appropriately used in evaluating actual and potential doses in the environs of DOE facilities?
  - Information on dispersion
  - Demography
  - Land use
  - Food supplies
  - Exposure pathways
- Is such information updated as necessary to document significant changes that could affect dose evaluations?
- Are dose evaluation models that are codified, approved, or accepted by regulatory or other authorities used where appropriate (e.g., AIRDOS/RADRISK codes to demonstrate compliance with 40 CFR 61, Subpart H)?
- Are the appropriate tables (of approved dose conversion factors listed below) used to evaluate doses unless otherwise legally required?
- Is the dose delivered to a body over the lifetime of the individual from a single committed dose used for calculation of dose to the public?
- Are these conversion factors based upon the ICRP Reference Man model, and the committed dose integrated over an interval of 50 years?

- Are doses from exposure to external radiation from radionuclide concentrations in air and in water, and that result from submersion or from exposure to contaminated plane surfaces estimated, as appropriate, using the external dose conversion factors presented in EPA-520/1-88-020 and in DOE/EH-0070?
- Are DCG values presented as reference values for:
  - Inhalation of air containing the radionuclide?
  - Submersion in a semi-infinite cloud of air containing the radionuclide?
  - Ingestion of water containing the radionuclide?
- Are the DCG tables used to evaluate the three exposure modes upon which they are based?
- Are other methods and alternatives, other than those discussed above, used as prescribed in applicable regulations, submitted to EH-1 for approval?
- Are dose limits for members of the general public, from routine operation of a DOE activity, expressed as a dose received by the individuals during the year or the committed dose received by the individual over a period of 50 years from radionuclides taken into the body during the year?
- Are doses calculated as realistically as practicable? In other words, are the individuals subject to the greatest exposure identified, to the extent practicable, so that the highest dose might be determined?
- If dose limits apply to actual or committed doses of real individuals, do all factors germane to dose determination apply?
- Alternately, if available data are not sufficient to evaluate these factors, or if they are too costly to determine, are the assumed parametric values sufficiently conservative so that it is unlikely that individuals would actually receive a dose that would exceed the dose calculated using the values assumed?
- Are parametric values, used in performing dose calculations, recorded?
- Is the collective public dose in the environs of a site, with multiple emission points, estimated using the assumption that all emissions occur from a single point centrally located on the site?
- Is the assumption of a single point of emission, as discussed above, used to calculate public dose for the maximally exposed individuals if the emission points are close to one another relative to the distance to the site boundary? Otherwise, is the public dose to the maximally exposed individuals determined taking into consideration the actual locations of emissions on the site with respect to the offsite locations?

In regard to both liquid and airborne effluent monitoring, the contractor would be required to consider the following for DOE/EH-0173T:

- Where are each of the effluent monitoring (sampling or in situ measurement) extraction locations used for providing quantitative effluent release or emission data for each outfall?
- What are the procedures used to perform the necessary extraction and measurement, and what equipment is needed?
- What is the analysis required for each extraction (continuous monitoring and/or sampling) location and how often should each be conducted?
- What are the minimum detection levels and what is the degree of accuracy required?
- What are the quality assurance components?
- What are the effluent outfall alarm settings and bases?
- What is the significance of investigations and alarm levels?

Activity 2, Solution
(Any reasonable paraphrase of the following is acceptable.)

You would have to maintain accurate documentation of how much tritium you actually use over the course of a year.

You would have to identify the maximum amount you would be able to dump down the drain and still be within the DOE guidelines.

You would then need to demonstrate that the amount dumped is only a small fraction of the amount you would be allowed to dump (under the Derived Concentration Guide values found in DOE 5400.5) and, therefore, is justified under your company's ALARA program.

No. The cutoff point for H-3 is 5.0 Ci/yr.

Activity 3, Solution
(Any reasonable paraphrase of the following is acceptable.)

Does it include an ALARA program, and does it:

- Provide language supportive of the ALARA program?
- Describe how the ALARA program will be carried out?
- Discuss how to document ALARA decisions?
- Provide staff training to implement the ALARA program?
- Evaluate factors for:
  - Maximum dose to public (individuals)?
  - Collective dose to population?
  - Alternative processes (e.g., alternative treatments of discharge streams, operating methods, or controls)?
  - Doses expected for each evaluated alternative?
  - Cost of each alternative?
  - Comparison of all alternative costs?
  - Impact of each alternative on the public, (e.g., differential doses from various pathways of exposure)?

Does it include a Best Available Technology (BAT) plan relative to the use of the BAT for processing liquid waste (as per 10 CFR 834*)?*

- Does the BAT plan:
  - Discuss how to determine if a BAT is required?
  - If required, discuss the results of the selection process?
  - Provide a schedule for implementing the BAT, where selected?
  - Discuss the following factors that need to be taken into consideration (relative to technology, economics, and public policy) in making a choice as to which BAT is best?
    + Age of equipment/facility
    + Process employed
    + Engineering aspects of control techniques
    + Process changes
    + Cost of achieving such an effluent reduction
    + Impact on environmental nonwater quality
    + Energy requirements

  + Safety considerations
  + Policy considerations

- Has a groundwater protection management plan been developed?
- Does this plan address radiological as well as nonradiological monitoring?
- Does plan conform with 10 CFR 834?
- Does it have a monitoring program that addresses both state and federal requirements?
- Does the plan:
  - Provide groundwater quality and quantity documentation?
  - Identify contamination sources?
  - Describe strategies for controlling contamination?
  - Describe measures for monitoring groundwater quality?
- Has an environmental monitoring plan (EMP) been developed?
  - Is it in compliance with 10 CFR 834, Subpart E?
- Are high-quality monitoring and surveillance activities, facilities, and locations used?
- Are practical and uniform strategies used to obtain information?
- Does the plan provide for effluent monitoring, to obtain representative measurements of the quantities and concentrations of pollutants in liquid and airborne discharges, and environmental surveillance, to monitor effects to the public and the natural environment?
- Does the plan:
  - Comply with 10 CFR 834 and other applicable federal environmental laws and regulations?
  - Provide rationale and design criteria for each element?
  - Include the extent and frequency of monitoring and measurements?
  - Provide procedures for laboratory analyses?
  - Examine implementation procedures?
  - Provide meteorological data?
  - Provide a preoperational study (in new activities/facilities)?
  - Provide effluent monitoring so as to:
    + Measure quantities and concentrations of liquid and airborne discharges?
    + Collect samples in such as way as to ensure that they are truly representative of the effluent streams?
    + Analyze samples adequately?
  - Conduct environmental surveillance so as to:
    + Establish background levels of pollutants?
    + Determine the location and magnitude of pollutant concentrations?
    + Evaluate the effects of pollutants on the public and the environment?

- Utilize monitoring stations based on:
  + Type of emission?
  + Meteorology?
  + Climatology?
  + Topography?
  + Geography?
  + Population distribution?
  + Land use?
  + Other relevant considerations?
- Collect and analyze samples in a manner and frequency sufficient to characterize the emissions and effects of an activity?
- Verify unexpected and undetected releases?
- Provide meteorological data:
  + Representative of the atmospheric transport and dispersion conditions in the vicinity of the activity?
  + Including precipitation, temperature, wind speed, wind direction, and atmospheric stability that are important to surveillance?
  + That is supportive of routine and nonroutine emissions assessment?
- Provide a preoperational study that:
  + Begins at least a year before the start up of a new activity/facility?
  + Characterizes existing physical, chemical, and biological conditions that could be affected?
  + Establishes background levels of radioactive/chemical components?
  + Characterizes pertinent environmental and ecological parameters?
  + Identifies potential pathways for human exposure or environmental impact?

Has a waste plan been developed?

Does the waste plan:

- Address the management, disposal, and storage of radioactive wastes?
- Address low-level, high-level, and transuranic wastes as well as residual radioactive material?
- Comply with 10 CFR 834 and other applicable federal regulations?
- Describe:
  - The means used to limit access to wastes?
  - Interim and long-term strategies for dealing with waste?
  - Administrative safeguards?
  - Mechanism for cooperating with state and local officials in regard to wastes?
  - The process for releasing property contaminated or potentially contaminated with residual radioactive materials.

Has a quality assurance program been developed that includes:

- Organizational responsibility?
- Program design?
- Procedures?
- Field quality design?
- Laboratory quality control?
- Human factors?
- Recordkeeping?
- Chain-of-custody procedures?
- Audits?
- Performance reporting?
- Independent data verification?

4. SUGGESTED ADDITIONAL READINGS AND/OR COURSES

Courses

- *Environmental Monitoring* -- Oak Ridge Institute for Science and Education.